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Abstract

The aim of this study was to examine swimmers' activity–technical device coupling during an experimental protocol (MADsystem).The study was conducted within a course-of-action theoretical and methodological framework. Two types of datawere collected: (a) video recordings and (b) verbalizations during post-protocol interviews. The data were processed in twosteps: (a) reconstruction of each swimmer's course of action and (b) comparison of the courses of action. Analysis from theactors' point of view allowed a description of swimmer–technical device coupling. The results showed that the technicaldevice modified the athletes' range of perceptions and repertoire of actions. They also indicated that changes in couplingbetween the swimmers and the MAD-system were linked to utilization constraints: the swimmers' experiences weretransformed in the same speed intervals, suggesting that this was an essential situational constraint to swimmer–technicaldevice coupling. This study highlights how a technical device and the conditions of its use changed athletes' activity andsuggests that it is important to develop activity-centred design in sport.

Keywords: Activity-oriented approach, technical device, course of action, swimming

Introduction

Biomechanical analyses in swimming usually requireequipment, tools, and technical devices to assesskinematic and kinetic measures that influence performance.However, few studies have examined howinteractions between swimmers and these technicaldevices affect swimming behaviour. This led us tofocus on swimmers' activity in these heavily instrumentedenvironments.Human locomotion in water poses the challenge ofoptimizing movement coordination to exploit aquaticresistance and so maximize propulsion while minimizingactive drag. It would therefore be informative toexamine how technical devices used to quantifypropulsion and active drag affect the motor habits ofswimmers. Indeed, most biomechanical studies usemeasurement devices that are wired to swimmers andmanipulated by the investigators. Since much of theenergy expenditure in swimming is used to overcomedrag, di Prampero and colleagues (di Prampero,Pendergast,Wilson, &Rennie, 1974) quantified activedrag from the variation in oxygen consumption thatresulted from additional forces used to overcome thedrag. Hollander et al. (1986) used a new system forthe Measurement of Active Drag (MAD-system),which directly measured the forces of the hand asit pushed off from a series of pads fixed on a rod.A third method, the speed-perturbation method,calculates the active drag by comparing two conditionsof swimming at maximal speed: swimming in a freecondition and swimming with an attached hydrodynamicbody that imposes additional resistance(Kolmogorov &Duplischeva, 1992; Toussaint, Roos,& Kolmogorov, 2004). In summary, the differenttechnical devices used to assess propulsive forcesand active drag modify swimming technique to varyingdegrees over that used in the ‘‘free’’ condition,suggesting that even if they provide valid and reliablemeasures, they could affect swimmers' activity. Abetter understanding of the coupling between theswimmer and the technical device is thus required, and the concept of activity provides a way of conceptualizing this coupling (Beguin, 2003; Leplat, 2001).The present study was conducted using an activity-oriented approach (Daniellou&Rabardel,2005). We opted for the course-of-action theoreticaland methodological framework (Theureau, 2002,2003), which has previously been used to analyse thecomponents of elite athletes' activity during competitionand training (e.g. d'Arripe-Longueville, Saury,Fournier, & Durand, 2001; Hauw, Berthelot, &Durand, 2003; Hauw& Durand, 2007; Se`ve, Poizat,Saury, & Durand, 2006). Course-of-action providesa means to study simultaneously characteristics of atechnical device and swimmers' activity. The theoryand method of course of action were developed inFrench ergonomics research (Daniellou, 2005) forthe analysis of occupational tasks and ergonomicconceptions of occupational settings. The course-ofactiontheory has been enriched by the work in ‘‘situatedaction/cognition’’ (Hutchins, 1995; Kirshner&Whitson, 1997; Lave, 1988; Suchman, 1987), whichpostulates that: (a) all activity is situated, meaningthat it cannot be dissociated from the context inwhich it takes shape, and must therefore be studiedin situ; and (b) a structural coupling defines therelationship between the actor and his or her environment.This coupling, which is continuously transformedoverthe course of activity, emerges fromactors' efforts to adapt to a context whose meaningfulelements are resources that they will use to act.According to course-of-action theory, couplingsbetween actors and environments are asymmetricin that they concern only those elements fromthe environment that the actors select moment bymoment as most relevant to their internal organization.Thus, to understand this coupling betweenactors and their material environment, the course-ofactionframework provides tools to study the meaningthat actors construct during these couplingsfrom their verbalizations. The course of action is thepart of activity that is meaningful for the actor. It canbe defined as follows: ‘‘the activity of a given actorengaged in a given physical and social environment,belonging to a given culture, where the activity ismeaningful for that actor; that is, he [sic] can show it,tell it and comment upon it to an observer-listenerat any instant during its unfolding’’ (Theureau&Jeffroy, 1994, p. 19). The semiological framework ofthe course of action is rooted in the hypothesis thatactors think (and act) through signs (Peirce, 1931–1935). The course of action is made up of a chainof signs that are meaningful units of activity emergingfrom the coupling between an actor and thecontext. By identifying these signs, the actor's courseof action is reconstructed, and this reconstructionprovides insight into the process by which meaning isbuilt during action.The aim of this study was to analyse the couplingbetween swimmers and a technical device (theMAD-system) during an experimental protocol.This was accomplished by first describing theswimmers’ activity as they used the device, particularlythe dynamics of change in two dimensions:the swimming mechanics (i.e. speed and force) andthe meaning that the swimmers themselves attributedto the activity (i.e. the swimmers’ report of theirexperience of swimming with the MAD-system).The starting point of this work was to questionthe prevailing assumption that these devices are‘‘content-free’’ (Dyson &Grineski, 2001): that is,independent of swimmers’ activity. Our researchassumption was that, since the environment continuouslystructures activity, it is important to examinein situ the dimensions of swimming activity thatemerge from the coupling of swimmers and a technicaldevice. These dimensions, notably dynamicand meaningful, are often overlooked in evaluationprotocols and yet they could be helpful in improvingtechnical design. We anticipated that: (a) the MADsystemwould change the usual activity of swimmersto a degree that exceeded the expectations of itsdesigners, and (b) the coupling between the swimmersand the MAD-system would be diverse.

Methods

Participants

Three international-standard male swimmers participatedin this study (Table I). The protocol wasexplained in full to them and they provided writtenconsent to participate in the study, which was approvedby the university ethics committee. Although theswimmers did not ask to remain anonymous, theywere given pseudonyms to maintain confidentiality:Max, Eric, and Luc.

Procedure

The protocol we chose for our study of swimmer–technical device coupling is often used in highstandard swimming to assess the relationshipsbetween speed and active drag and so evaluateswimmers’ body shape. The experimental protocolwas undertaken in a 25-m swimming pool.

Table I. Main characteristics of the swimmers.

Swimmer	Age (years)	Experience (years)	Weekly training volume (h)	Time for 100-m freestyle in 50-m pool (s)
Max	20	9	10	50.3
Eric	22	13	10	50.1
Luc	22	10	10	52.3

Theswimmers were all swimming for the first time on the MAD-system. They had to swim ten 25-m lapswith each lap at a different but constant speed. Arest period of 3 min was taken between laps. Theparticipants were given no specific instructions abouttimes for each lap: they were only given feedback ontheir performance time for each lap and were askedto swim the next lap a little bit faster than in theprevious lap. For the last two laps (9 and 10), theinstructions were to swim as fast as possible. Toensure that the laps were swum at maximal speed,the experimental protocol usually gives the swimmerstwo trials (Toussaint van der Meer, de Niet, &Truijens, 2006). Table II gives the speed and forcefor each lap.Using the MAD-system (Hollander et al., 1986),the swimmers pushed off from a fixed pad with eachstroke, with a total of 16 pads. The swimmers usedtheir arms only and their legs were supported by asmall pull-buoy. The pads were attached to a 22-mrod, which was mounted 0.8 m below the watersurface. The distance between the push-off pads was1.35 m. The rod was connected to a force transducerfor direct measurement of the push-off force for eachstroke.

Data collection

Two types of data were gathered: (a) continuousvideo recordings of the swimmers' behaviours duringthe experimental protocol and (b) their verbalizationsduring post-protocol interviews.The behaviours of the three swimmers during theexperiment were recorded with three digital cameras(Figure 1). The first camera recorded an aerial,frontal, and wide-angle view of the swimmers. Thesecond camera was placed in a waterproof box andwas positioned underwater, 20 m from the edge ofthe pool. A diver experienced in underwater filming recorded the contacts between the swimmers' handsand the MAD-system pads as accurately as possible.

Table II. Swimmers' speed and force for each lap when using the MAD-system.

	Speed ($m \cdot s^{-1}$)/ Force (N)		
Lap	Max	Eric	Luc
1	1.02/28	1.27/37	1.16/34
2	1.20/40	1.42/44	1.19/37
3	1.27/44	1.54/52	1.35/47
4	1.35/51	1.62/58	1.47/53
5	1.46/58	1.71/66	1.58/62
6	1.54/66	1.72/70	1.68/74
7	1.62/72	1.80/81	1.77/84
8	1.72/85	1.84/89	1.86/96
9	1.83/96	1.90/92	1.94/103
10	1.91/107	1.88/97	1.95/111

The third camera was positioned close to the edge ofthe pool and recorded complementary ethnographicdata.The verbalization data were gathered from individualself-confrontation interviews with the swimmers.This interview consists of confronting a personwith his or her activity in a particular situation(Theureau, 2003). The present interviews wereconducted immediately after the experimental protocoland lasted about 30 min. During each interview,the swimmer viewed the videotape of thelaps together with one of the present authors. Theswimmer was asked to describe and comment on hisactivity during each lap. He was invited to reconstructand share his personal experience during theaction viewed on the videotape, and not to justifyor explain it. During the interviews, the researchersought to keep the swimmer's attention on the studytopic with specific questioning (Theureau, 2006).The researcher's prompts concerned sensations (e.g.what sensations are you experiencing here?), perceptions(e.g. what are you perceiving here?), focus (e.g.what are you paying attention to here?), concerns(e.g. what are you trying to do here?), thoughts andinterpretations (e.g. what are you thinking here?),and emotions (e.g. what emotions are you experiencinghere?). All the interviews were conductedby a researcher who had already conducted selfconfrontationinterviews of this type in previousresearch.

Data processing

The verbal exchanges between the swimmer and theresearcher during the interview were recorded andfully transcribed. The data were processed in twosteps: (a) reconstruction of each swimmer's course ofaction and (b) comparison of these courses of action.Reconstructing each swimmer's course of action This step consisted of identifying and documentingthe six components of the hexadic signs that constitutethe course of action.

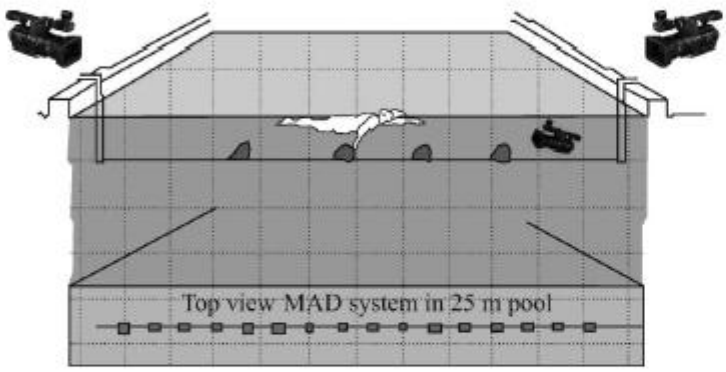

Figure 1. Positions of the three cameras.

When asked to describetheir activity, actors spontaneously break down a continuous stream of activity into discrete units thathave personal meaning. It is assumed that thesediscrete units are the expression of a sign, termed''hexadic'', as it consists of six components: the unitof course of action (U), the representamen (R), theinvolvement in the situation (E), the anticipatorystructure (A), the referential (S), and the interpretant(I) (Theureau, 2003, 2006). For each course ofaction, the components of the hexadic signs weredocumented step-by-step on the basis of (a) thevideo recording, (b) the verbalization transcript, and(c) specific questioning.The unit of course-of-action (U) is the fraction ofpre-reflexive activity that can be shown, told, andcommented on by the actor. The unit could be asymbolic construct, physical action, interpretation oremotion. It was identified by asking the followingquestions about the collected and transcribed data:What is the swimmer doing? What is he thinking?What is he feeling?The representamen (R) corresponds to the elementsthat are taken into account by the actor at agiven moment. The representamen can be perceptiveor mnemonic. It was identified by asking thefollowing questions about the collected and transcribeddata: What is the significant element for theswimmer in this situation? What element of the situationis he considering? What element is being remembered,perceived or interpreted by the swimmer?The involvement in the situation (E) correspondsto the actor's concerns at a given moment. Theseconcerns arise from past courses of action. Theinvolvement in the situation was identified by askingthe following question about the collected and transcribeddata: What are the swimmer's notable concernsabout the element being taken into account inthe situation?The anticipatory structure (A) corresponds to theelements expected by the actor in his or her dynamicsituation at a given moment, taking into account theinvolvement. It was identified by asking the followingquestion about the collected and transcribed data:What are the swimmer's expectations at this instantwith regard to his concerns and the elements he findsmeaningful in this situation?The referential (S) corresponds to the actor'sknowledge, inherited from past experiences that heor she can mobilize at a given moment, taking intoaccount the involvement and the potential actuality.It was identified by asking the following questionabout the collected and transcribed data: Whatknowledge is being mobilized by the swimmer atthis instant in the situation?The interpretant (I) corresponds to the validationand extension of past knowledge and theconstruction of new knowledge at a given instant.It was identified by the following question aboutthe collected and transcribed data: What element ofknowledge is the swimmer validating, invalidating orconstructing at this moment?As our focus was on the swimmer–device coupling,we were particularly interested in the unit ofcourse of action (physical actions, interpretations),the representamen, and the involvement.Comparison of the swimmers' courses of actionTo describe and understand how the three swimmersinteracted with the technical device, we comparedtheir courses of action for each lap. The simultaneousanalyses of the unit of course of action, representamen,and involvement of each swimmer allowed usto specify the convergent or divergent character oftheir experiences. This analysis revealed both uniqueoccurrences and recurrences in the swimmers' activitywhile interacting with the MAD-system. The recurrenceswere the expression of typical couplingsbetween the swimmers and the technical device.Trustworthiness of the data and analysisSeveral measures were taken to enhance the credibilityof the data (Lincoln &Guba, 1985). First, theinterviews were conducted in an atmosphere oftrust between the swimmers and researcher. Second,the transcripts were presented to the participantsso that they could ensure the authenticity of theircommentary and make any necessary changes to thetext. Minor editorial comments were made to confrontationalresponses. Third, the data were codedindependently by two trained investigators. Thesetwo researchers had already coded protocols of thistype in previous studies and were accustomed tocourse-of-action theory.

Results

Analysis of changes in the swimmers' experienceshowed (a) convergence of their experiences duringthe first three laps and the last three laps and (b) thedivergence of their experiences during laps 4–7. Astheir experience was transformed in the same speedintervals, this seems to have been an essential situationalconstraint to the swimmer–technical devicecoupling. For this reason, we chose to organize theresults around this feature of the context. The resultsare presented in three stages: (a) swimmer–MADsystemcoupling in the context of slow speeds, (b)swimmer–MAD-system coupling in the context ofmedium speeds, and (c) swimmer–MAD-systemcoupling in the context of maximum speeds. Foreach stage, we identified the concerns and themodifications in the usual activity of the swimmers.Swimmer–MAD-system coupling in the context of slowSpeedsDuring the first three laps, we identified two majorconcerns of the swimmers. The first was to put theirhands on each pad and not to miss any: ''Here I'mthinking about trying to see where the other pad willbe because otherwise I might miss it, be too short ortoo long'' (Luc). The second concern was to placetheir hands correctly and, more specifically, to setthem down flat on the pads: ''Here I'm trying tofind the right position for my hand. I try to have mywhole hand on the pad'' (Max). The aim was to beneither too far forward nor too far backward of thepad to avoid grabbing it by the fingertips: ''In fact,during my first lap I was too far behind the pad andso I was forced to grasp it and pull it. Whereas duringmy second lap I am more forward and I can wedgemy arm behind it better so that I can push on thepad better'' (Luc). To place their hands flat on eachpad, the swimmers changed their usual swimmingactivity. First, they raised their heads to look at thepads: ''In fact, the marker, the pad, we look at it firstof all because they are lined up one by one'' (Eric);''I'm not holding my head in the same position aswhen I swim naturally . . . As soon as I finish mypush-off, I put my head up a little to see where thenext pad is'' (Luc). They also changed the positioningof their body segments: ''When you swim, theelbow is like this [makes a 908 angle with the arm andforearm] and here in fact it's like this [makes a 458angle] because the pads are aligned and thereforethe catch is not as deep'' (Eric). This modificationaccompanied a change in the trajectory of theirarms in and out of the water: ''My shoulder isalso less engaged compared to my usual stroke . . . Idon't have this forward and downward phase wheremy shoulder is working when I catch the water''(Max).Swimmer–MAD-system coupling in the context ofmedium speedsDuring laps 4–7, each swimmer developed his ownmodality of using the technical device to deal withthe speed constraints imposed by the protocol: (a)press quickly on the first pads with rhythm (Max),(b) press hard on the first pads (Luc), and (c) presshard on the pads in the middle of the pool (Eric).

Max: ''Press quickly on the first pads with rhythm''.After the fourth lap, Max wanted to press faster onthe first four pads and then maintain the acquiredmomentum. His concern was to save time by notkeeping his hand too long on the pads. To ensure thebrevity of the hand push-off, he tried to lay his handsvery quickly on the top of the pads and to accelerateat the end of each push: ‘‘I’m not going to acceleratein a linear fashion. In the beginning, I will dofour pads. You see, I start faster and then I keepgoing . . . I try to take them faster . . . I look only atthe top [of the pads]. I don’t need to take twoseconds to reach the pad and lay my hand on it. It’s awaste of time’’.

Luc: ‘‘Press hard on the first pads’’. After the fifthlap, Luc first tried to press hard on the first threepads: ‘‘I would say that I press hard on the first threepads’’. To do so, he pressed on the first pad with hisstronger arm, the right one: ‘‘I start with the rightarm because it’s my stronger arm; since I needmaximum power in the beginning, I always start withthe right arm’’. Starting with the right arm allowedhim to push twice with his more powerful arm on thefirst three pads.

Eric: ‘‘Press hard on the pads in the middle of thepool’’. To move fast, Eric tried to press hard onthe pads in the middle of the pool: ‘‘Especially in themiddle, you tend to press hard’’. Unlike the otherswimmers, Eric pushed against the wall with his feetto start fast: ‘‘In fact, in the beginning, you don’treally press on the pads as you push against thewall’’. With this push, he gained speed, which hemaintained up to the middle of the pool: ‘‘Well, Idon’t press too much, I push against the wall. Weseriously start the movements after the fifth pad, infact’’. Then he regained speed by pressing hard onthe pads in the middle of the pool, and then as heapproached the end of the pool he ended his efforts:‘‘It’s only on the last one I don’t push because it’snear the wall’’.

Swimmer–MAD-system coupling in the context ofmaximum speeds

During the last three laps, the swimmers sought toincrease arm-stroke rate to reach maximum speeds.However, the regular spacing of the pads made itdifficult for the swimmers to increase their strokerate: ‘‘It’s different with fast strokes. Generallyspeaking, you have a high amplitude when you swimslowly, so here the problem is the regular intervals.We’re not able to adapt’’ (Eric). Each swimmerattempted to use the same modality of interactingwith the technical device as during the mediumspeedlaps, as they continued trying to lay their handsregularly on each pad at high speed. Their activitywas structured from one pad to the next: ‘‘Because it goes so quickly, at the moment my hand is about totouch one pad I’m already thinking about the nextpad’’ (Max). The increasing speed made laying thehands on the pads more random: ‘‘What is differentis also the way we will lay the palm of our hands, notalways right on top of the pad . . .’’ (Eric). To be able to lay their hands on each pad while swimming fast, the swimmers sought a compromise between a behaviour that guaranteed control of the placement of their hands on the pads and a behaviour that favoured a good chronometric performance. Lucand Eric lifted their heads slightly to see the pads,but took care not to alter the streamlining of theirbody: ‘‘We have to avoid excessive focus on the pads,otherwise we’re like this [he straightens his headupward]. I try to keep my head down as much aspossible and not look up to see every pad . . .’’ (Luc).As for Max, he shortened the beginning of each armmovement: ‘‘I zap the first part of the catch phase.Usually I stay longer with my hand ahead to makesure of a good catch. I shorten it a bit to be able tocatch the pad at once because on the MAD-systemyou can swim even if you skip a pad''.

Discussion

This study of swimmers' activity during instrumentedprotocols revealed that substantially more occursduring these protocols than what is actually soughtor assessed. Although our results must be generalizedwith caution because of the small number of participants,they showed that (a) the swimmer–technicaldevice coupling is a dynamic process of adaptationand (b) this process leads both to idiosyncratic andtypical forms of coupling with the device.The swimmer–technical device coupling as a dynamicprocess of adaptationOur results indicate modifications in the forms ofcoupling with the MAD-system over the course ofthe ten 25-m laps. These modifications were relatedto the constraint characteristics of the device (e.g. thealignment of pads) and the changes in the protocolconditions (e.g. the increasing speed). They reflectedthe situated character of the swimmers' activity.

Thus, certain forms of the observed couplings werenot anticipated by the researchers. Although theincreasing lap speeds suggested that we would see alinear change in the forces exerted on the pads, weinstead noted propulsive strategies designed to takeadvantage of the protocol (Suchman, 1987). Ourposition about the design of technical devices isgenerally at odds with that conveyed in experimentalprotocols. The general assumption is that these deviceshave objective properties that: (a) promote theachievement of the tasks specified by the designerand (b) support the effects expected by the experimenter(Norman, 1988, 1993). Several studies inoccupational settings have shown that the modalitiesof interaction and the characteristics of a technicaldevice reveal themselves during use in a dynamicfashion (e.g. Rabardel&Beguin, 2005). Specifically,these studies have shown that activity cannot bereduced to the conditions prescribed by the protocoldesigner and that the actor–technical device interactionsare indexed to other components of theenvironment and to the dynamics of the actor'songoing activity. Modifications observed in athlete–technical device couplings have indicated the mediatingrole of objects in the interaction of actorswith their environment (Stewart, Khatchatourov, &Lenay, 2004). In the present swimmer–environmentcoupling, the MAD-system contributed to definingboth the activity and the situation: (a) the technicaldevice modified the swimmers' range of possibleperceptions and repertory of possible actions and(b) it contributed to defining the swimmers' ''world''by modifying relevant elements of the environmentwith which they were interacting. Yet, despite thedynamic and opportunistic nature of the forms ofcoupling, this does not imply that the modalitiesof using a protocol cannot be stabilized. In fact,complementary study is needed to analysedevicedependentprotocols over longer periods to determinethe learning processes by which the device isappropriated by swimmers and incorporated intotheir activity.Some forms of idiosyncratic and typical couplingsOur results revealed the complexity of athletes'activity during experimental protocols. This complexitywas manifested in the swimmer–technical devicecoupling by idiosyncratic elements that expressedan asymmetric coupling of the actors with theirenvironment (e.g. Conein&Jacopin, 1993) andrecurring elements that indicated common modalitiesof adapting to the technical device.Our results show a personalization of the use of thetechnical device (Dodier, 1993), especially duringlaps 4–7. Each swimmer had a strategy to mobilizepropelling surfaces or to distribute forces. They usedthe MAD-system differently: (a) press quickly on thefirst pads with rhythm, (b) press hard on the firstpads, or (c) press hard on the pads in the middle ofthe pool.During the interaction between an actor anda technical device, an ‘‘instrumental genesis’’ occurs(Rabardel, 2001). This genesis refers to the user'sprocess of adapting to the device, which materializesas a change in the actor's movements (Norman,1988, 1993). The personal adaptations of our swimmersconfirmed the notion that actors construct theirworlds in great part through their interactions withtheir environment (Von Uexku¨ ll, 1956–1965). In addition to their idiosyncratic adaptations, ourresults also showed recurrences in the swimmer–technical device coupling. For example, the swimmers'investigations at the beginning of the protocolor their attempts to adapt their high speed stroke during the last three laps indicated activity characterizedby careful focusing on the spatial arrangementof the pads (Salembier, Theureau, Zouina, &Vermeesch, 2001). Moreover, all the swimmerschanged their usual head position: they raised it alittle to check where the next pad would be. In certainconditions (e.g. in the context of slow or maximumspeeds), these high-standard swimmers had similarcoupling with the MAD-system and modified theiractivity for the same elements. These observationssuggest that swimmers' behaviour while using technicaldevices can only be understood by simultaneouslytaking into account the objective constraints,such as the imposed speeds of a protocol, andthe processes of instrumental genesis: that is, theswimmers' subjective interpretations about the constraintsand the swimming actions reuired to adapt.In other words, when the environmental constraintsare experienced as insurmountable disturbances fromthe swimmers' point of view, for example while usingthe MAD-system at slow and maximum speeds,they contribute to the emergence of new forms ofswimming activity, which are almost identical for allswimmers. When the constraints are experienced assurmountable disturbances, for example while usingthe device at a medium swim speed, swimmersare more at ease (Relieu, 1993): the device becomesinconspicuous, as for example in this study wherethe interval between pads was not as disturbingat medium speed as it was at slow and maximumspeeds. The swimmers could thus adapt to theenvironment while still maintaining traces of theirhabitual swim technique.

Concluding remarks

This study has highlighted typical processes ofadaptation that should be useful for the design ofnew technical devices. During the design of atechnical device, disproportionate attention is paidto the technical specifications, with little thoughtgiven to the future user. However, a purely technologicalapproach to design could create problems forthe user. It is therefore important (a) to ensure thatthe user's activity becomes a source for the designer'sactivity and (b) to take into account the situationsin which the technical devices are used. It isthus important to develop activity-centred design insport (Gay &Hembrooke, 2004; Norman, 2006;Theureau, 2003). Our activity-oriented approachhighlights some rarely considered dimensions oftechnical devices that could lead to improvementsin their design and the situations in which they areused. As an illustration, one recommendation mightbe to use the MAD-system at swimmers' ‘‘medium’’speed during evaluation protocols so that eachswimmer can improve the appropriation of thedevice and experience it as easy to use. Anotherrecommendation concerns design: perhaps inter-paddistances should be modulated in the future inaccordance with the speed imposed by the protocol.

Although experimental protocols impose numerousconstraints, two criteria for the design of technicaldevices are essential: usability and appropriation.To be as effective as possible without imposing anadditional constraint on the user, the technicaldevice has to: (a) correspond to the essential characteristicsof the activity to which it is dedicated and(b) facilitate the idiosyncratic and typical adaptationsof the athletes in situation.

References

Beguin, D. (2003). Design as a mutual learning process betweenusers and designers. Interacting with Computers, 15, 709–730.

Conein, B., &Jacopin, E. (1993). Les objets dans l'espace: Laplanification dans l'action [Objects in space: Planning inaction]. Raisons Pratiques, 4, 59–84.

Daniellou, F. (2005). The French-speaking ergonomists' approachto work activity: Cross-influences of field interventionand conceptual models. Theoretical Issues in Ergonomics Science,6, 409–427.

Daniellou, F., &Rabardel, P. (2005). Activity-oriented approachesto ergonomics: Some traditions and communities.Theoretical Issues in Ergonomics Science, 6, 353–357.

D'Arripe-Longueville, F., Saury, J., Fournier, J., & Durand, M.(2001). Coach–athlete interaction during elite archery competitions:An application of methodological frameworks used inergonomics research to sport psychology. Journal of AppliedSport Psychology, 13, 275–299.

Di Prampero, P. E., Pendergast, D. R., Wilson D. R., &Rennie,D. W. (1974). Energetics of swimming man. Journal of AppliedPhysiology, 37, 1–5.

Dodier, N. (1993). Les arènes des habiletés techniques [Thearenas of technicalskills]. Raisons Pratiques, 4, 115–139.

Dyson, B., &Grineski, S. (2001). Using cooperative learningstructures to achieve quality physical education. Journal ofPhysical Education, Recreation, and Dance, 72, 28–31.

Gay, G., &Hembrooke, H. (2004). Activity-centered design: Anecological approach to designing smart tools and usable systems.Cambridge, MA: MIT Press.

Hauw, D., Berthelot, C., & Durand, M. (2003).Enhancingperformance in elite athletes through situated-cognition analysis:Trampolinists' course of action during competition activity.International Journal of Sport Psychology, 34, 299–321.

Hauw, D., & Durand, M. (2007).Situated analysis of elitetrampolinists' problems in competition using retrospectiveinterviews. Journal of Sports Sciences, 25, 173–183.

Hollander, A. P., de Groot, G., van IngenSchenau, G. J.,Toussaint, H. M., de Best, H., & Peeters, W. (1986).Measurement of active drag forces during swimming, Journalof Sports Sciences, 4, 21–30.

Hutchins, E. (1995). Cognition in the wild. Cambridge, MA: MITPress.

Kirshner, D., & Whitson, J. A. (1997). Situated cognition: Social,semiotic and psychological perspectives. Mahwah, NJ: LawrenceErlbaum Associates.

Kolmogorov, S. V., &Duplischeva O. A. (1992).Active drag,useful mechanical power output and hydrodynamic forcecoefficient in different swimming strokes at maximal velocity.Journal of Biomechanics, 25, 311–318.

Lave, J. (1988). Cognition in practice: Mind, mathematics and culturein everyday life. Cambridge: Cambridge University Press.

Leplat, J. (2001). L'analyse du travail en psychologie ergonomique[Workanalysis in ergonomicpsychology] (Vol. 1). Toulouse,France: Octare`s.

Lincoln, Y. S., &Guba, E. G. (1985).Naturalistic inquiry. BeverlyHills, CA: Sage.

Norman, D. A. (1988).The psychology of everyday things. NewYork: Basic Books.

Norman, D. A. (1993). Things that make us smart: Defending humanattributes in the age of the machine. New York: Addison-Wesley.

Norman, D. A. (2006). Logic versus usage: The case for activitycentereddesign. Interactions, 13, 45-ff.

Peirce, C. S. (1931–1935). The collected papers of Charles SandersPeirce (Vols. 1–6, edited by C. Hartshorne & P. Weiss).Cambridge, MA: Harvard University Press.

Rabardel, P. (2001). Instrument mediated activity in situations:People and computer. In A. Blandford, J. Vanderdonckt, &P. Gray (Eds.), Interaction without frontiers (pp. 17–30). London:Springer.

Rabardel, P., &Beguin, P. (2005). Instrument mediated activity:From subject development to anthropocentric design. TheoreticalIssues in Ergonomics Science, 6, 429–461.

Relieu, M. (1993). Travaux en public. La dynamique d'unesituation problématique. [Public works: The dynamics of aproblematic situation]. Raisons Pratiques, 10, 95–117.

Salembier, P., Theureau, J., Zouina, M., &Vermeesch, P. (2001).Action/cognition situéeet assistance à la coopération [Situated action/cognition and assistance to cooperation]. Communication to the 12th French-speaking Congress on KnowledgeEngineering (IC'2001), Grenoble, France, June.

Sève, C., Poizat, G., Saury, J., & Durand, M. (2006).A groundedtheory of elite male table tennis players' activity during matches.The Sport Psychologist, 20, 58–73.

Stewart, J., Khatchatourov, A., &Lenay, C. (2004). Enaction andengineering. Communication to the Interdisciplines VirtualWorkshop ''Enactive Network of Excellence'' Retrieved February20, 2005, from: http://www.interdisciplines.org/enaction/papers/7/version/original

Suchman, L. (1987). Plans and situated action. Cambridge:Cambridge University Press.

Theureau, J. (2002). Dynamic, living, social and cultural complexsystems: Principles of design-oriented analysis. Revue d'IntelligenceArtificielle, 16, 485–516.

Theureau, J. (2003). Course of action analysis and course of actioncentered design. In E. Hollnagel (Ed.), Handbook of cognitivetask design (pp. 55–81). Mahwah, NJ: Lawrence ErlbaumAssociates.

Theureau, J. (2006). Cours d'action: Méthode développée [Course ofaction: Developments in methods]. Toulouse, France: Octarès.

Theureau, J., &Jeffroy, F. (1994). Ergonomie des situationsinformatisées [Ergonomy in situations of computer use]. Toulouse, France: Octarès.

Toussaint, H. M., Roos, P. E., & Kolmogorov, S. (2004). Thedetermination of drag in front crawl swimming. Journal ofBiomechanics, 37, 1655–1663.

Toussaint, H. M., van der Meer, S., de Niet, M., &Truijens, M. (2006). Propelling efficiency in sprint front crawl swimming.Portuguese Journal of Sports Sciences, 6 (suppl. 2), 279–282.

Von Uexküll, J. V. (1956–1965). Mondesanimauxet monde humain [Animal worlds and the human world]. Paris: Denoël.1050 A. David et al.Downloaded